

EXHIBIT B

ARC Professional Services Group

C³I Systems Division

COMPATIBILITY ASSESSMENT OF THE AMATEUR SERVICE IN THE 216-220 MHz BAND

Prepared for
The American Radio Relay League

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COMPATIBILITY ASSESSMENT OF THE AMATEUR SERVICE IN THE 216-220 MHz BAND

1. INTRODUCTION

1.1 Objective

The objective of this study was to determine the potential for sharing between incumbent services (including the recently proposed Interactive Video Data Service, IVDS) and the Amateur service in the 216-220 MHz band.

1.2 Approach

An assessment was made of the domestic allocation tables to determine what services may be operating in the 216-220 MHz band. Representative equipment characteristics for systems in these services were compiled. An electromagnetic compatibility analysis was then performed to determine the frequency sharing possibilities between the incumbent and amateur services. This analysis concentrated on frequency-distance (F-D) separation constraints that were calculated according to Equation 1 as presented in CCIR Report 654:

$$L_b(d) + FDR(\Delta f) \geq P_t + G_t + G_r - I_m \quad (1)$$

where

- $L_b(d)$ = basic transmission loss for a separation distance, d , between transmitter and receiver, (dB);
- $FDR(\Delta f)$ = Frequency Dependent Rejection (dB), given a frequency offset, f , between the transmitter and receiver tuned frequencies;
- P_t = transmitter power (dBW);
- G_t = gain of transmitter antenna in the direction of the receiver (dBi);
- G_r = gain of receiver antenna in the direction of the interferer (dBi);
- I_m = maximum permissible interference power (dBW).

Basic transmission losses, $L_b(d)$, were calculated for an interfering signal path over medium dry ground assuming a smooth spherical earth. This loss calculation does not account for varying terrain, buildings, or other shielding normally found in an operating environment. These additional factors tend to significantly reduce the required distance or frequency separation. In addition, the assumed emission spectra and receiver selectivity characteristics were chosen conservatively to yield

greater frequency separation constraints than are likely to be required. Further, mainbeam-to-mainbeam antenna coupling were assumed with no polarization discrimination. Consequently, the approach used in this study yields conservatively high estimates of the sharing constraints; actual frequency-distance separations will be substantially smaller than the worst-case situations calculated herein for sharing feasibility purposes. Other cases with more typical parameters are also addressed.

2.0 BAND ALLOCATION AND USAGE

The 216-220 MHz band is allocated to the Maritime Mobile Service on a primary basis (see Table 1). A previous geographic restriction, limiting operations to the Mississippi River, Gulf Intracoastal Waterways, and the Gulf of Mexico, has been removed by a January 1991 First Report and Order [RM-5712]. Aeronautical mobile, fixed, and land mobile services also are allocated on a secondary basis and typically are used for telemetry and telecommand purposes. In addition, the Government has a secondary allocation for the Radiolocation Service.

A recent NTIA study [NTIA, 5-1] indicates that the 216-220 MHz band is sparsely used by both Government and non-Government services (see Table 2). The FCC Frequency Master List shows that approximately 1000 licensees are authorized with a majority being in the mobile services. In addition, the NTIA report states that few assignments have been made to Government users.

A new service, the Interactive Video Data Service (IVDS), has been recently proposed for operation in the 218-218.5 MHz band [FCC, RM-6196] to provide real-time responses from television viewers. IVDS, if allocated, would be part of the Private Radio Service.

3.0 CONSTRAINTS ON SHARING BETWEEN AMATEUR TRANSMITTERS AND RECEIVERS IN OTHER SERVICES

3.1 Assumptions

Table 3 lists the parameters used in the calculation of the frequency-distance curves. These parameters are considered to be representative of worst-case systems; hence, the results provide a good basis to determine an upper bound on the sharing constraints between services. It is understood that a wide range of equipment may be deployed, however, any variations between the assumed and actual system parameters should not greatly increase, but may greatly decrease, the sharing constraints shown in the results of this study.

One of the most obvious deviations from the assumed parameters that would occur in practice is with respect to antenna polarization and pointing, which has been assumed to be co-polar and mainbeam-to-mainbeam, respectively. In cases where the ama-

TABLE 1 - TABLE OF FREQUENCY ALLOCATIONS

INTERNATIONAL			UNITED STATES				
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4	Remarks 5
613 614 615	613 616 617 618		161.575-161.625	US77 613		MARITIME MOBILE NG6 NG17	
			161.625-161.775	613		LAND MOBILE NG6	Remote pickup broadcast.
			161.775- 162.0125	US266 613		MARITIME MOBILE NG6	
			162.0125-173.2	US8 US11 US13 US216 US223 US300 613	FIXED MOBILE G5		The Channeling Plan for assignments in this Band is shown in Section 4.3.7 of the NTIA Manual.
			173.2-173.4			FIXED Land Mobile NG124	Industrial Public safety
			173.4-174		FIXED MOBILE G5		The Channeling Plan for assignments in this Band is shown in Section 4.3.7 of the NTIA Manual.
174-223 BROADCASTING	174-216 BROADCASTING Fixed Mobile 620	174-223 FIXED MOBILE BROADCASTING	174-216			BROADCASTING NG115	Television broadcasting
621 623 628 629	216-220 FIXED MARITIME MOBILE Radiolocation 627	619 624 625 626 630	216-220	US210 US229 US274 627	Radiolocation Fixed MARITIME MOBILE Land Mobile Aeronautical Mobile G2	MARITIME MOBILE Fixed Land Mobile Aeronautical Mobile NG121	

**TABLE 2 - DISTRIBUTION OF FREQUENCY
ASSIGNMENTS IN THE 216-220 MHz BAND**

SERVICE	GOVERNMENT	NON-GOVERNMENT	TOTAL/SERVICE
MOBILE	78	567	645
LAND MOBILE	13	24	37
RADIOLOCATION	27	0	27
AERONAUTICAL MOBILE	5	0	5
FIXED	141	33	174
NO SPECIFIC	20	80	100
TOTAL			988

TABLE 3
ASSUMED CHARACTERISTICS FOR SERVICES IN THE 216-220 MHz BAND

	MARITIME MOBILE	LAND MOBILE	TELEMETRY	RADIOLOCATION	IVDS
POWER OUTPUT	50 W	100 W	4 W	758.6 kW	20 W
EMISSION DESIGNATOR	16K0F3E	20K0F3E	10K0F2D	2HD0NON	50K0V1D
ANTENNA GAIN (dBi)	6	3	3	13 (sidelobe)	0
EMISSION SPECTRA					
3 dB	5	20	10	0.4	50
20 dB	14	-	13.9	2	-
40 dB	18	30	-	10	170
60 dB	25	62.5	-	20	396
70 dB		77	36.2	-	-
IF SELECTIVITY					
3 dB	14	20	10	15	50
20 dB	16	-	13.9	16	-
40 dB	25	30	-	-	170
60 dB	32	62.5	-	18	396
70 dB		77	36.2	-	-
ROLLOFF (dB/dec)	20	20	20	10 (xmit) 20 (rec)	20
SENSITIVITY (dBm)	-116	-113	-122	-160	-111
CRITERIA	12 SINAD	12 SINAD	12 SINAD		
ANTENNA TYPE	COLLINEAR	COLLINEAR	YAGI	LINEAR ARRAY	OMNI
ANTENNA HEIGHT (m)	30 (base)	30 (base)	2	2	36.6 (base) 6 (remote)

TABLE 3 (cont)
ASSUMED CHARACTERISTICS FOR SERVICES IN THE 216-220 MHz BAND

	AMATEUR PACKET	AMATEUR REPEATER	AMTS	BROADCASTING	AERONAUTICAL MOBILE	FIXED
POWER OUTPUT	50 W	100 W	50 W	25 kW	10 W	220 W
EMISSION DESIGNATOR	75K0F1D	16K0F3E	10K0F1B	5M75C3F	20K0F3E	176K0F9
ANTENNA GAIN (dBi)	6	9	0	12	12	12.8
EMISSION SPECTRA						
3 dB	75	16	10	4000	20	176
20 dB		20	13.9	4750		
40 dB	108	26		5800		
60 dB		30		8800		
70 dB			36.2	14400	77	
IF SELECTIVITY						
3 dB	75	16	10	4000	20	775
20 dB		20	13.9	4750		
40 dB	108	26		5800		
60 dB		30		8800		
70 dB			36.2	14400	77	
ROLLOFF (dB/dec)	20	20	20	40	20	40
SENSITIVITY (dBm)	-116	-120	-116	-93	-116	-93
CRITERIA	12 SINAD	12 SINAD	12	Grade B Contour	12 SINAD	
ANTENNA TYPE	YAGI *	COLLINEAR *	OMNI	LOG PERIODIC	COLLINEAR	
ANTENNA HEIGHT (m)	30	30	30	6 (rec) 492 (xmit)	3049	30

* For non-worst-case situations, the amateur antenna is assumed to provide at least 12 dB of discrimination via orthogonal polarization or azimuthally directive antennas.

teur station antenna is not pointed in the direction of the station in the other service, or orthogonal polarizations are used, upwards of 12 dB of discrimination would be readily available. These more typical cases (those with at least 12 dB of antenna discrimination) are discussed below; however, the worst-case propagation assumptions are retained.

3.2 Results

The frequency-distance separation curves are shown in Figures 1-18 and can be found at the end of this report. Figures 1-9 show results for amateur packet radio operations, and Figures 10-18 show results for amateur repeater operations. Each figure shows curves of the frequency-distance separations for the amateur system as the transmitter and as the receiver using the worst-case approach and assumptions discussed above. Example basic transmission loss curves are shown in Figures 19-21 to illustrate the conservative nature of the analysis.

The worst-case results of the amateur packet and amateur repeater analyses are summarized in Tables 4 and 5, respectively, and are discussed below.

3.2.1 Maritime Mobile

Using the worst-case assumptions, co-channel operation would require up to 120 km of distance separation to protect a maritime receiver from a amateur packet transmitter and up to 181 km of distance separation for an amateur repeater transmitter. The separations required to prevent interference to a maritime mobile receiver are relatively small with more than 100 kHz of off-tuning. This distance falls off rapidly with frequency offset such that with 200 kHz of frequency separation, up to about a 30 km separation may be necessary for compatible operation with packet radios and up to 11 km may be needed for repeater operation.

Considering again the co-channel sharing situation, the required distance separation would be less than 70 km in typical cases where 12 dB of discrimination is available relative to the worst-case (e.g., 12 dB discrimination from the polarization or non-mainbeam coupling of the amateur station antenna).

3.2.2 Land Mobile

Using the worst-case assumptions, land mobile receivers can be protected from co-channel amateur packet and repeater transmitters with 161 km and 228 km, respectively, of distance separation. Only 200 kHz of frequency separation provides a large reduction in the distance necessary. For an amateur packet transmitter the required distance is up to 37 km; up to 15 km from an amateur repeater.

Considering again the co-channel sharing situation, the

TABLE 4 - SUMMARY OF CALCULATED F-D SEPARATIONS

Interferer	Receiver	Distance Separation (km)		
		Co-Channel	200 kHz	1 MHz
Amateur Packet	Maritime Mobile	119.80	30.4	15.4
Maritime Mobile	Amateur Packet	104.30	27.2	13.1
Amateur Packet	Land Mobile	160.70	37.4	20.9
Land Mobile	Amateur Packet	103.10	27.2	13.1
Amateur Packet	Telemetry	65.70	7.6	3.4
Telemetry	Amateur Packet	53.50	4.7	2.1
Amateur Packet	Radiolocation	215.30	29.4	14.7
Radiolocation	Amateur Packet	629.00	79	64.9
Amateur Packet	IVDS	122.10	24.5	11.1
IVDS	Amateur Packet	100.60	29	14.3
Amateur Packet	AMTS	86.90	17.9	7.7
AMTS	Amateur Packet	103.90	27.1	13.1
Amateur Packet	Television	N/A	N/A	N/A
Television	Amateur Packet	N/A	N/A	N/A
Amateur Packet	Aero Mobile	341.00	199.6	76.6
Aero Mobile	Amateur Packet	297.70	157.2	21.2
Amateur Packet	Fixed	83.50	83.5	54.5
Fixed	Amateur Packet	207.10	94.6	52.1

TABLE 5 - SUMMARY OF CALCULATED F-D SEPARATIONS

Interferer	Receiver	Distance Separation (km)		
		Co-Channel	200 kHz	1 MHz
Amateur Repeater	Maritime Mobile	181.10	11.4	4.9
Maritime Mobile	Amateur Repeater	165.20	10.4	4.6
Amateur Repeater	Land Mobile	227.50	14.6	6.3
Land Mobile	Amateur Repeater	153.20	8.8	3.6
Amateur Repeater	Telemetry	70.10	1.6	0.8
Telemetry	Amateur Repeater	58.30	1	0.5
Amateur Repeater	Radiolocation	317.10	9.9	4.4
Radiolocation	Amateur Repeater	576.30	58.7	48.8
Amateur Repeater	IVDS	169.60	19.1	8.1
IVDS	Amateur Repeater	86.40	10.6	4.2
Amateur Repeater	AMTS	91.60	3.3	0.7
AMTS	Amateur Repeater	124.40	6.2	1.8
Amateur Repeater	Television	N/A	N/A	N/A
Television	Amateur Repeater	N/A	N/A	N/A
Amateur Repeater	Aero Mobile	403.70	28.5	4.5
Aero Mobile	Amateur Repeater	331.70	8.5	0.0
Amateur Repeater	Fixed	78.90	78.9	50.3
Fixed	Amateur Repeater	181.60	89.7	48.2

required distance separation would be less than 90 km in typical cases where 12 dB of discrimination is available relative to the worst-case (e.g., 12 dB discrimination from the polarization or non-mainbeam coupling of the amateur station antenna).

3.2.3 Telemetry

Using the worst-case assumptions, telemetry equipment requires the smallest frequency and distance separations of any of the services analyzed. Co-channel operation requires under 70 km of distance separation, and less than 8 km with 200 kHz of frequency separation.

Considering again the co-channel sharing situation, the required distance separation would be less than 40 km in typical cases where 12 dB of discrimination is available relative to the worst-case (e.g., 12 dB discrimination from the polarization or non-mainbeam coupling of the amateur station antenna).

3.2.4 Radiolocation

Using the worst-case assumptions, co-channel operation of the Navy SPASUR receiver require up to 317 km of distance separation from an amateur repeater; however, if the repeater operates 200 kHz from the radar, only 9.9 km or less is necessary. To adequately protect the SPASUR, an amateur packet system would need to be up to 215 km from the radar; with 200 kHz of frequency separation, 29 km or less may be necessary.

Considering again the co-channel sharing situation, the required distance separation would be less than 130 km in typical cases where 12 dB of discrimination is available relative to the worst-case (e.g., 12 dB discrimination from the polarization or non-mainbeam coupling of the amateur station antenna).

3.2.5 Interactive Video Data Service

Using the worst-case assumptions, distance separations of as much as 170 km may be necessary for a co-channel amateur transmitter to operate with an IVDS system. Substantial distance reduction (to separations of less than 25 km) can be achieved with 200 kHz of frequency separation.

Considering again the co-channel sharing situation, the required distance separation would be less than 65 km in typical cases where 12 dB of discrimination is available relative to the worst-case (e.g., 12 dB discrimination from the polarization or non-mainbeam coupling of the amateur station antenna).

3.2.6 Automated Maritime Telecommunications Systems (AMTS)

Using the worst-case assumptions, amateur repeater and packet transmitters can operate co-channel with AMTS systems with distance separations of less than 92 km.

Considering again the co-channel sharing situation, the required distance separation would be less than 50 km in typical cases where 12 dB of discrimination is available relative to the worst-case (e.g., 12 dB discrimination from the polarization or non-mainbeam coupling of the amateur station antenna).

3.2.7 Television

At 216 MHz, the lower frequency limit of this study, the frequency separation is 4.75 MHz from the video carrier frequency. At this frequency and with the worst-case assumptions, a minimum distance separation of up to 11 km from the television Grade B contour is required to prevent interference. Frequency separations greater than 6.75 MHz (i.e., amateur transmitter operating above 218 MHz) enables distance separations of less than 8 km. Further examination of TV receiver selectivity details show that co-location of amateur transmitters and TV receivers at Grade B contour is possible at frequencies in the 216-220 MHz range (as is the case for other systems). Since these distances and frequency offsets are based on a Grade B contour, it is implied that smaller distances would be necessary within the Grade B contour where higher television signal strengths occur (e.g., inside the Grade A contour). With additional loss typically available (non-worst-case situations), cosite operation of amateur transmitters and television receivers should be possible above 216 MHz.

3.2.8 Aeronautical Mobile

Using the worst-case assumptions, for co-channel operation, the aeronautical mobile service requires 403 and 341 km between amateur repeater and packet systems, respectively. In an amateur repeater environment, 200 kHz of off-tuning lowers the distance to less than 29 km; up to 200 km is required for operation with packet radio.

Considering again the co-channel sharing situation, the required distance separation would be less than 240 km in typical cases where 12 dB of discrimination is available relative to the worst-case (e.g., 12 dB discrimination from the polarization or non-mainbeam coupling of the amateur station antenna).

3.2.9 Fixed

Using the worst-case assumptions, less than 80 km will allow co-channel operation between amateur systems and the fixed service. Additional frequency separation gradually provides additional attenuation.

Considering again the co-channel sharing situation, the required distance separation would be less than 45 km in typical cases where 12 dB of discrimination is available relative to the worst-case (e.g., 12 dB discrimination from the polarization or non-mainbeam coupling of the amateur station antenna).

4.0 CONSTRAINTS ON SHARING WITH AMATEUR RECEIVERS

Frequency-distance results similar to those of Section 3.2 were obtained for receivers in the amateur service sharing frequencies with transmitters in the other services studied. These results are also plotted in Figures 1-18.

5.0 CONCLUSIONS

Given that band usage is currently very sparse, the amateur service could effectively operate in the 216-220 MHz band subject to appropriate frequency and distance separation constraints (i.e., as is the case with respect to amateur systems sharing with fixed and mobile services in the 220-225 MHz band). The constraints calculated in this study indicate that substantial spectrum resources would be available to the amateur service in the 216-220 MHz band throughout the U.S., even if usage of the band by other services grows substantially beyond the levels shown in Table 1. Imposition of technical standards (e.g., power limits) on the amateur service operations in this band could theoretically help bound the frequency-distance sharing constraints, but also may preclude amateur operations that would otherwise be possible. However, reductions in the amateur transmitter power levels assumed here (50 W and 100 W) is unlikely to significantly reduce sharing constraints. In any case, the amateur community would have to exert careful frequency management in order to assure that unacceptable interference will not occur to its own systems and to systems in other services.

6.0 RECOMMENDATIONS

In order to prevent interference to other services in the 216-220 MHz band, it is recommended that the amateur community adopt the following measures:

- 1) Develop and maintain a data base of current assignments in other services;
- 2) Determine the frequency constraints to prevent interference, on a case-by-case basis, for each planned amateur station;
- 3) Update the frequency constraints required of amateur stations at an operational site as new assignments are made to stations in other services, as appropriate.

REFERENCES

CCIR, "Protection Ratios Required for Spectrum Utilization Investigations", Report 525, (Geneva, ITU, 1986), I, 96.

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FIGURE 1 WORST-CASE SHARING CONSTRAINTS
FOR AMATEUR PACKET and MARITIME MOBILE

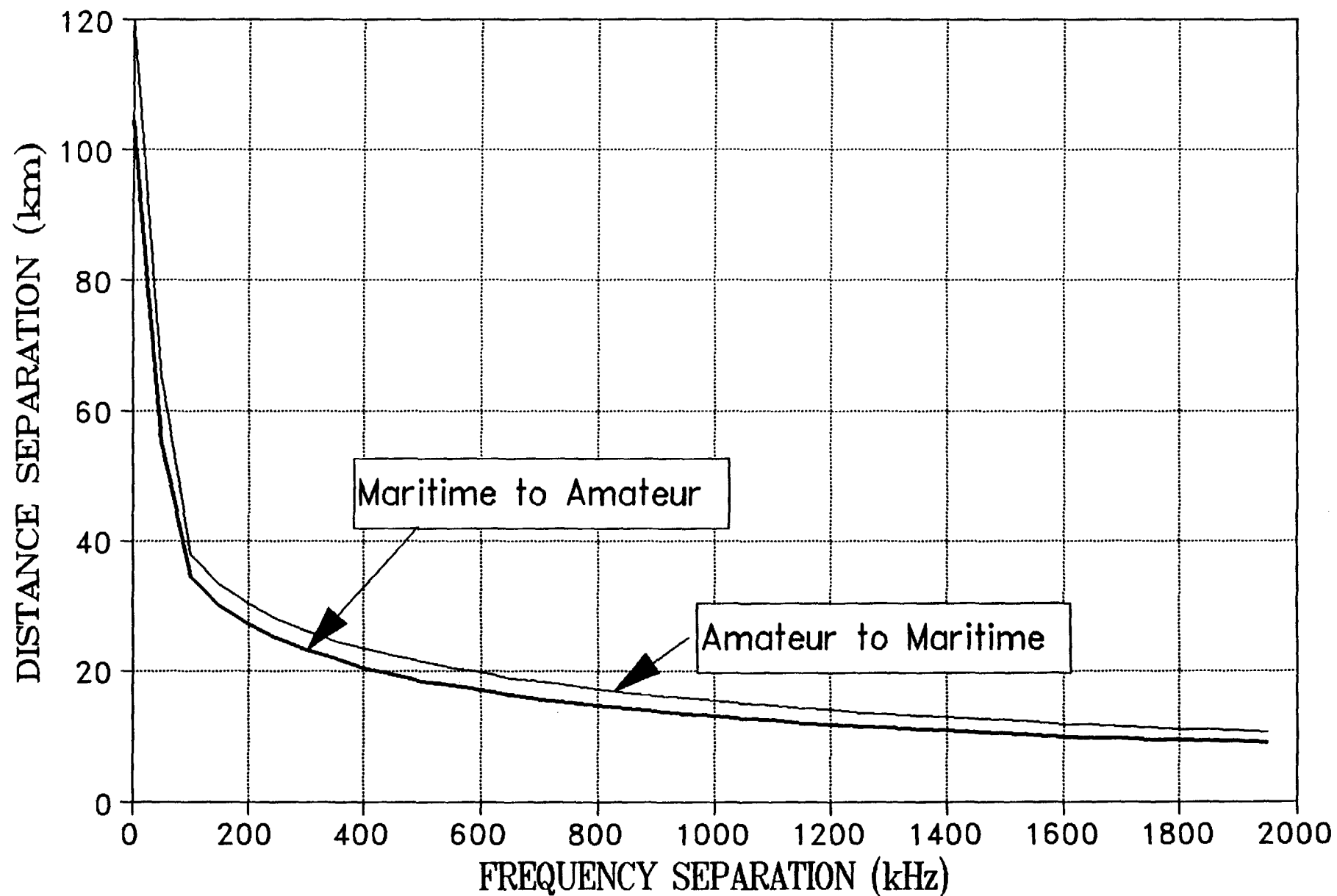


FIGURE 2 WORST-CASE SHARING CONSTRAINTS
FOR AMATEUR PACKET and LAND MOBILE

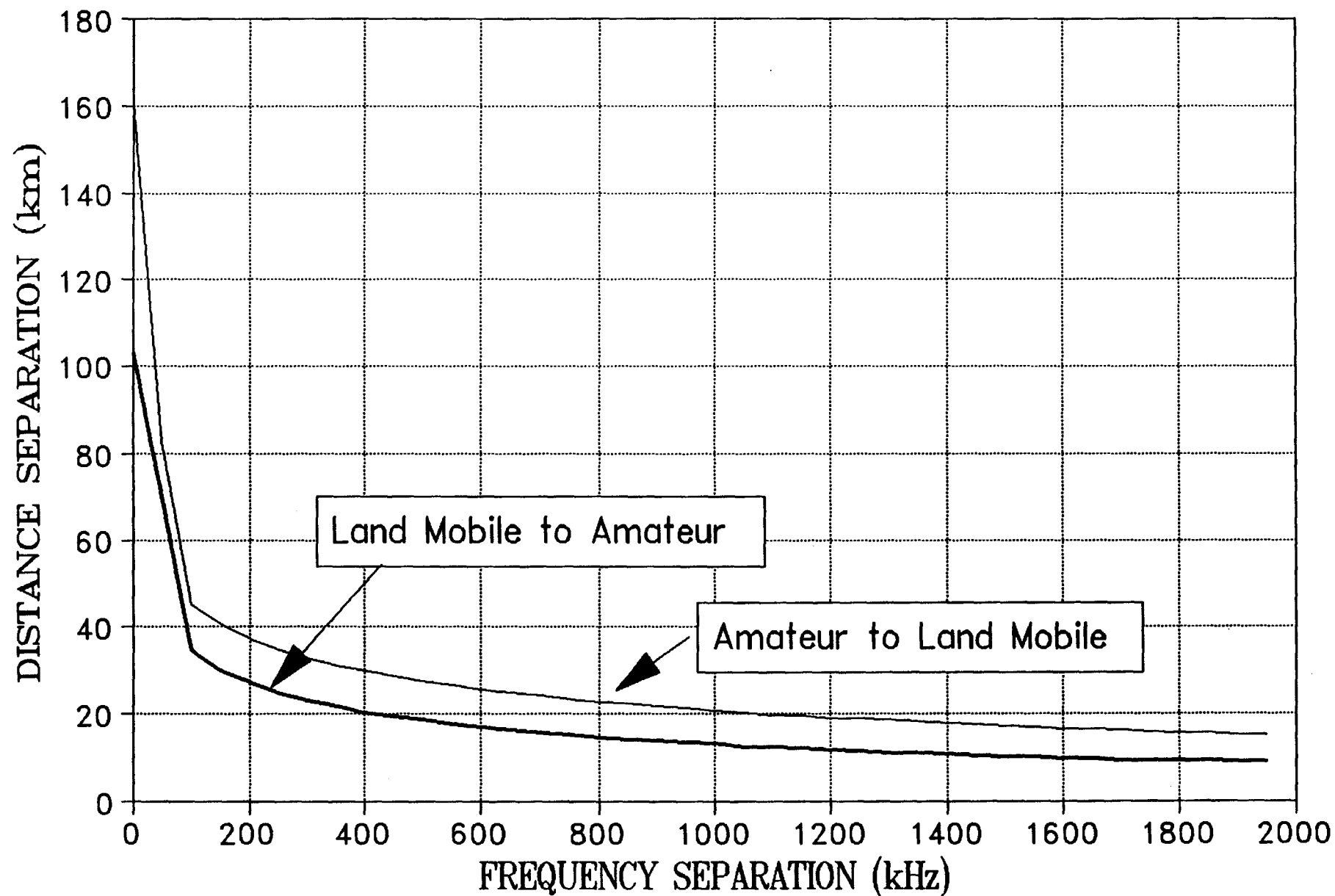


FIGURE 3 WORST-CASE SHARING CONSTRAINTS
FOR AMATEUR PACKET and TELEMETRY

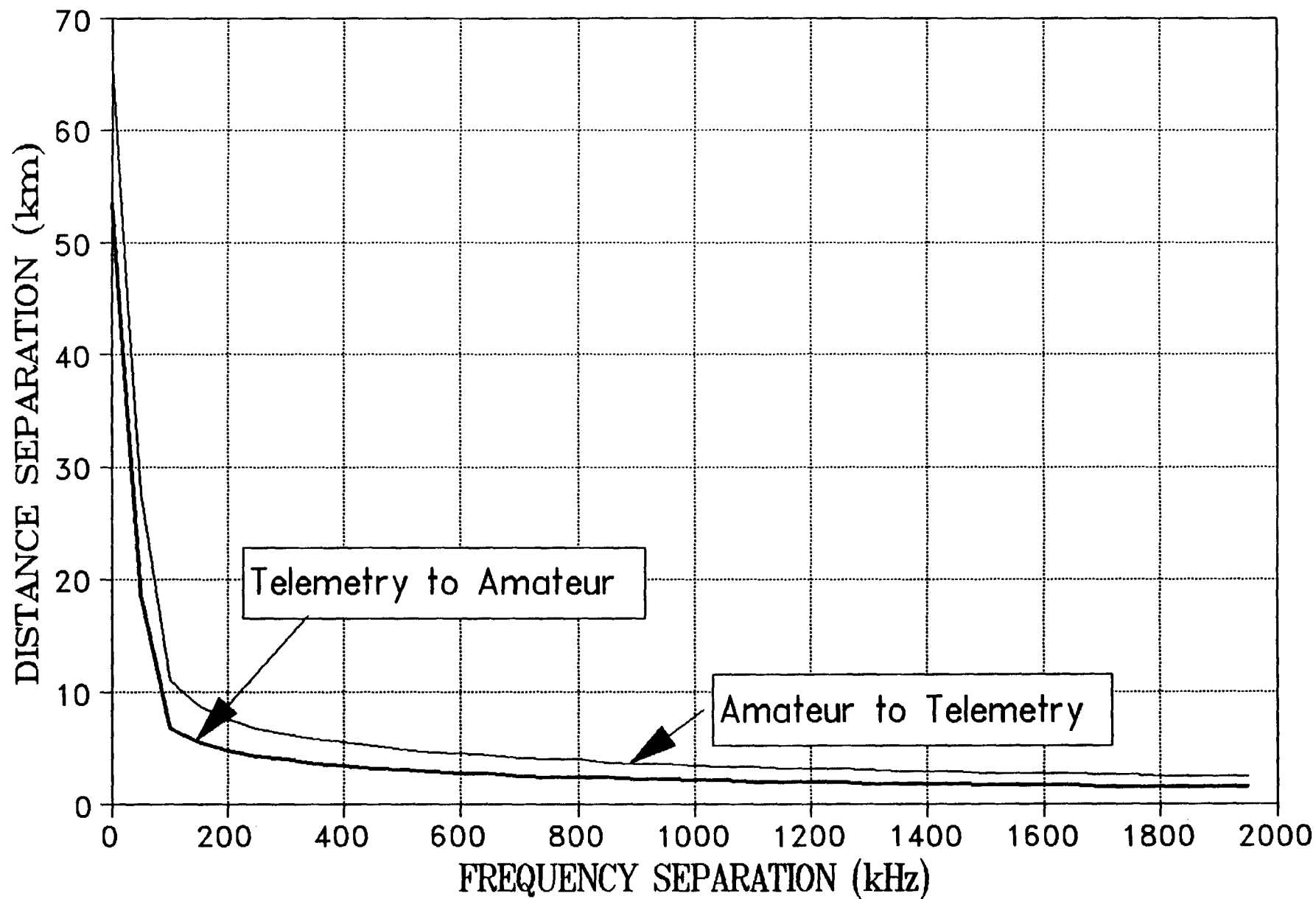


FIGURE 4 WORST-CASE SHARING CONSTRAINTS
FOR AMATEUR PACKET & RADIOLOCATION

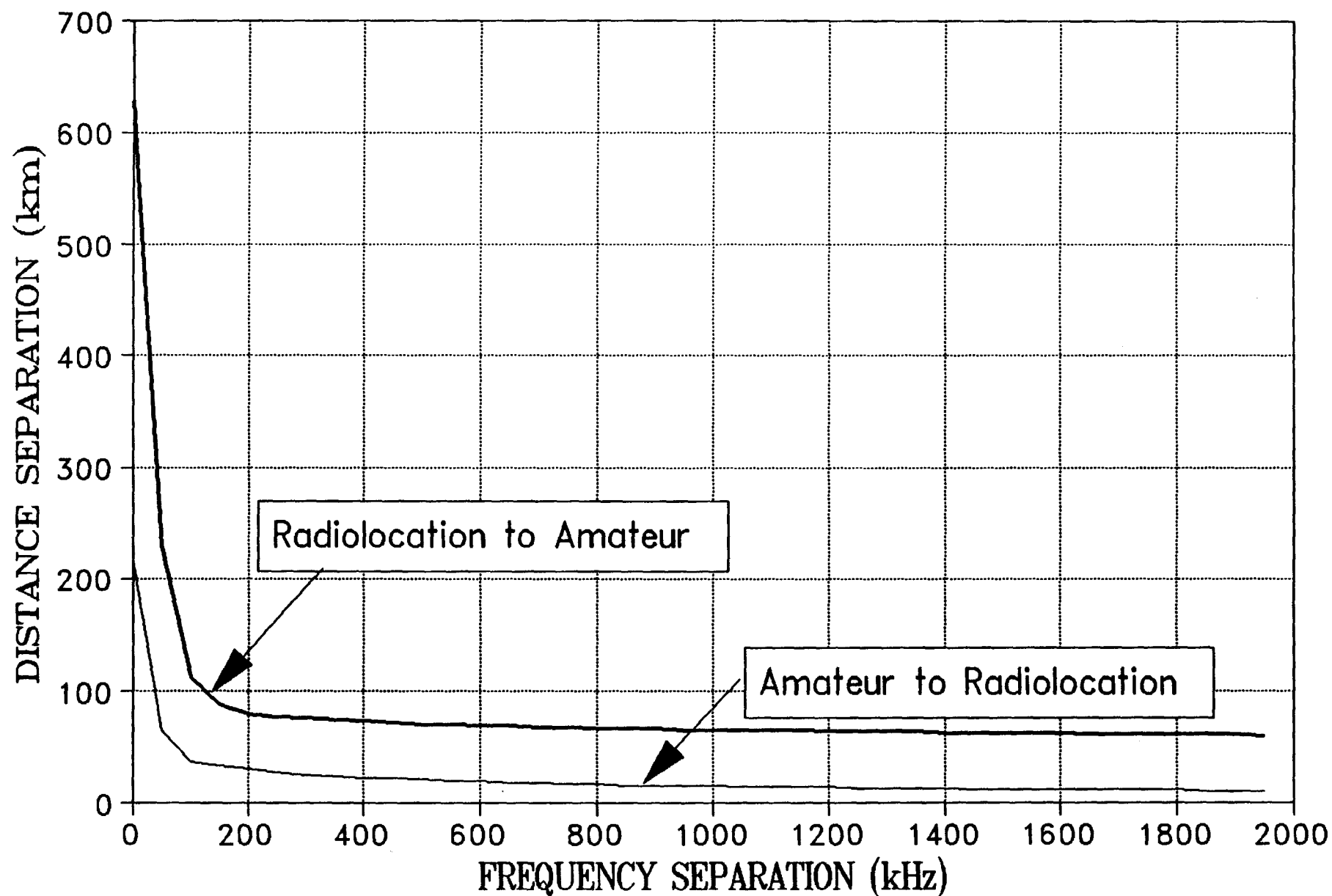


FIGURE 5 – WORST-CASE SHARING
CONSTRAINTS FOR AMATEUR PACKET AND IVDS

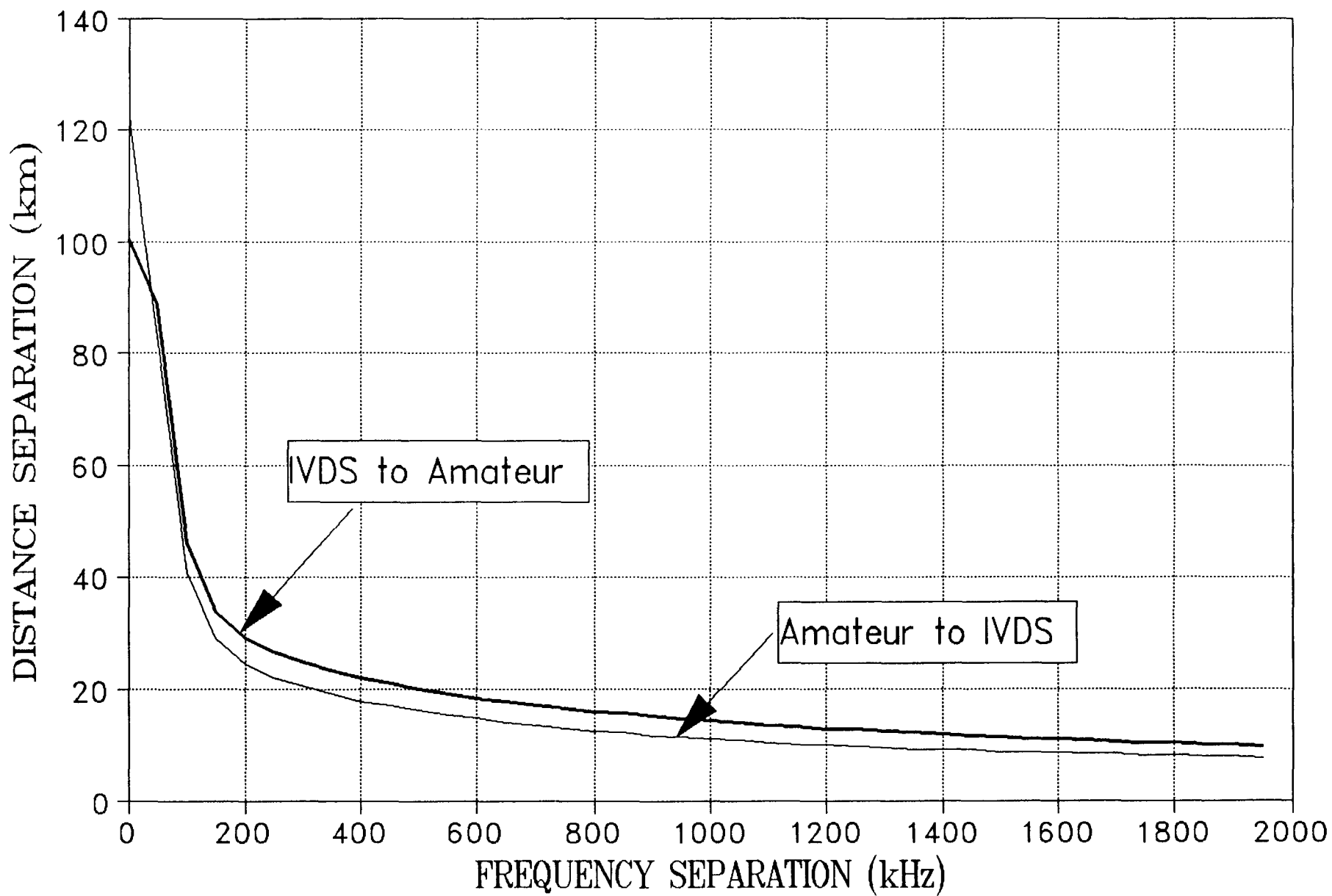


FIGURE 6 WORST-CASE SHARING CONSTRAINTS
FOR AMATEUR PACKET and AMTS

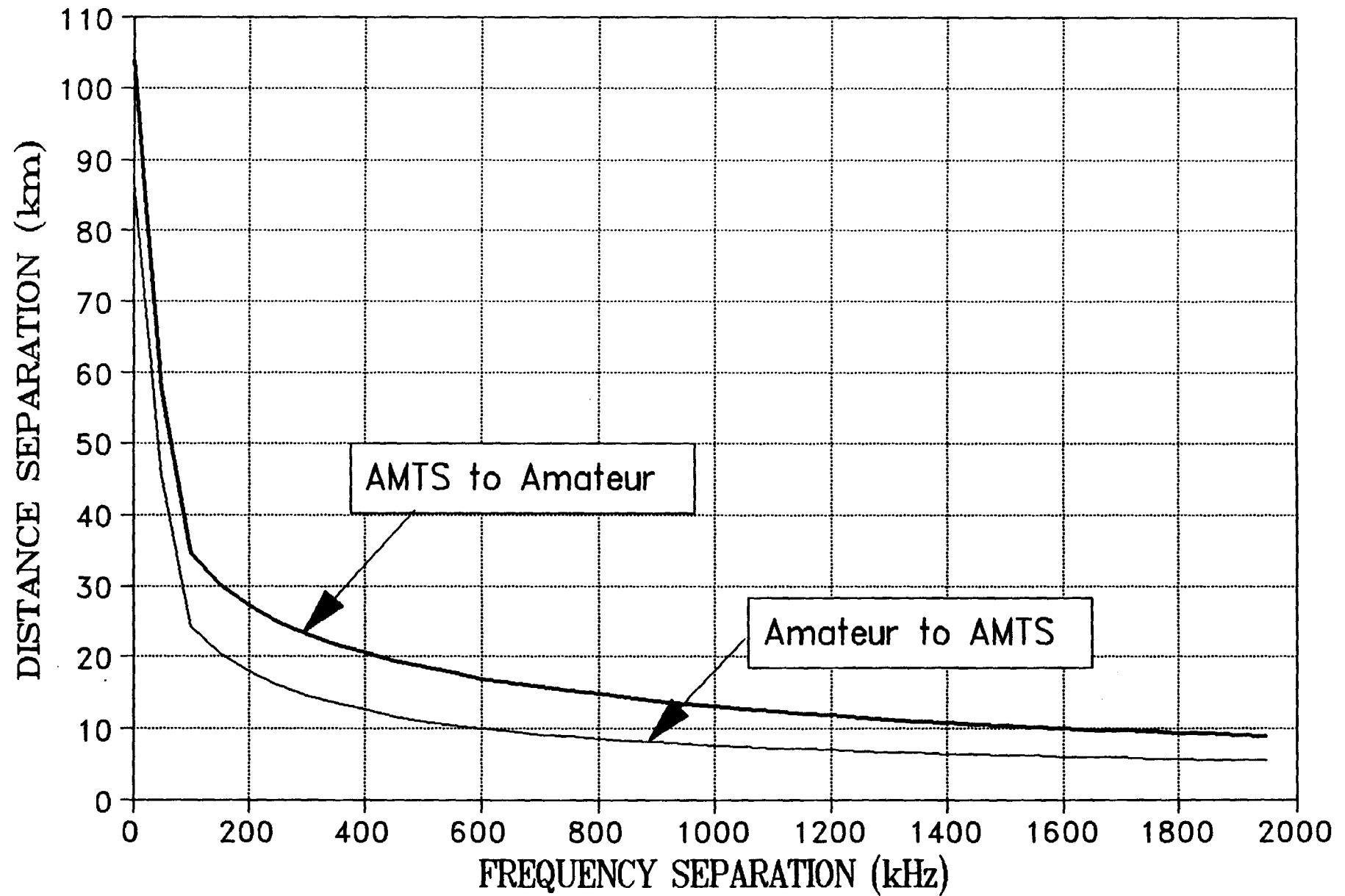


FIGURE 7 WORST-CASE SHARING CONSTRAINTS
FOR AMATEUR PACKET and TELEVISION

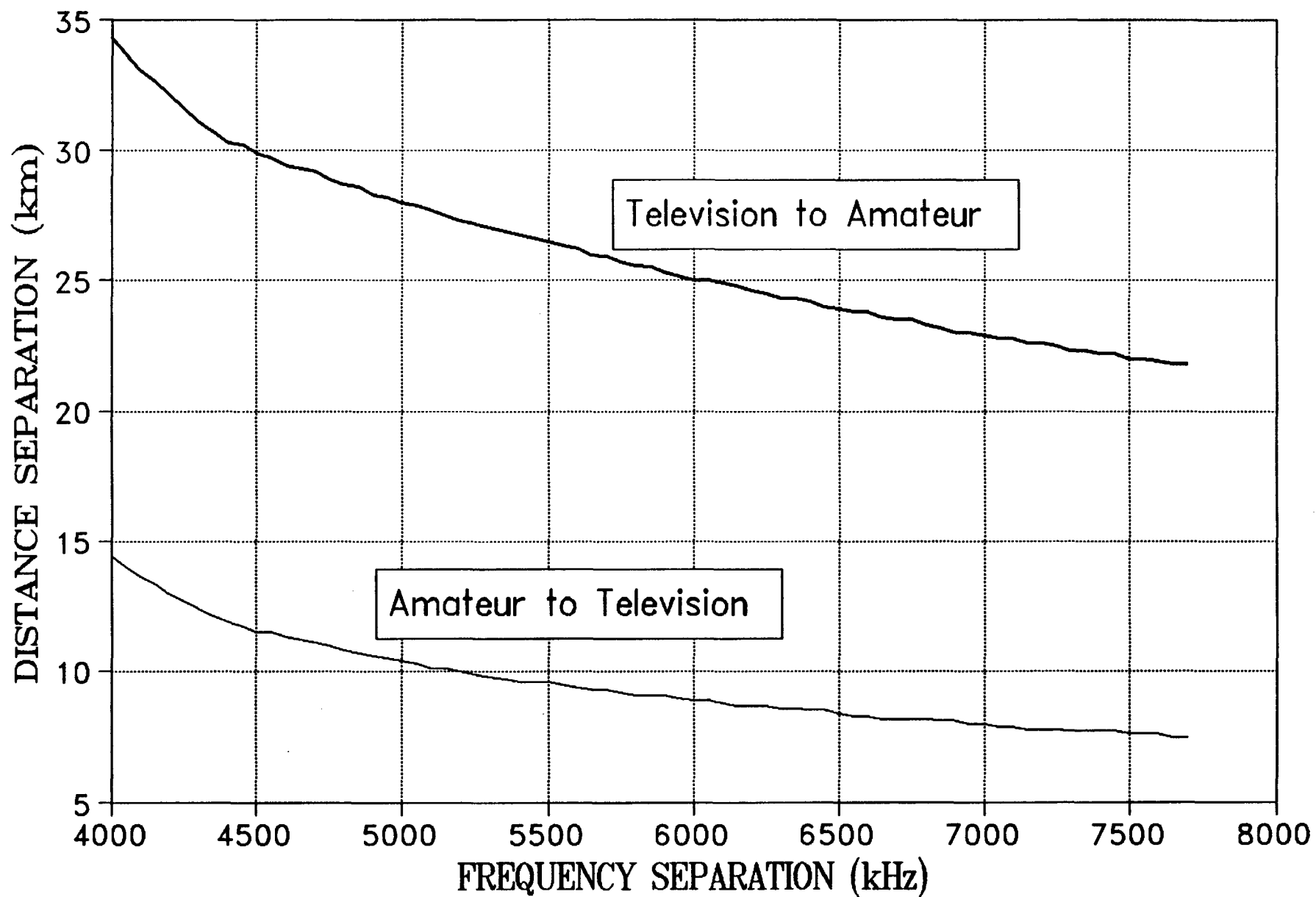


FIGURE 8 WORST-CASE SHARING CONSTRAINTS
FOR AMATEUR PACKET and AERO MOBILE

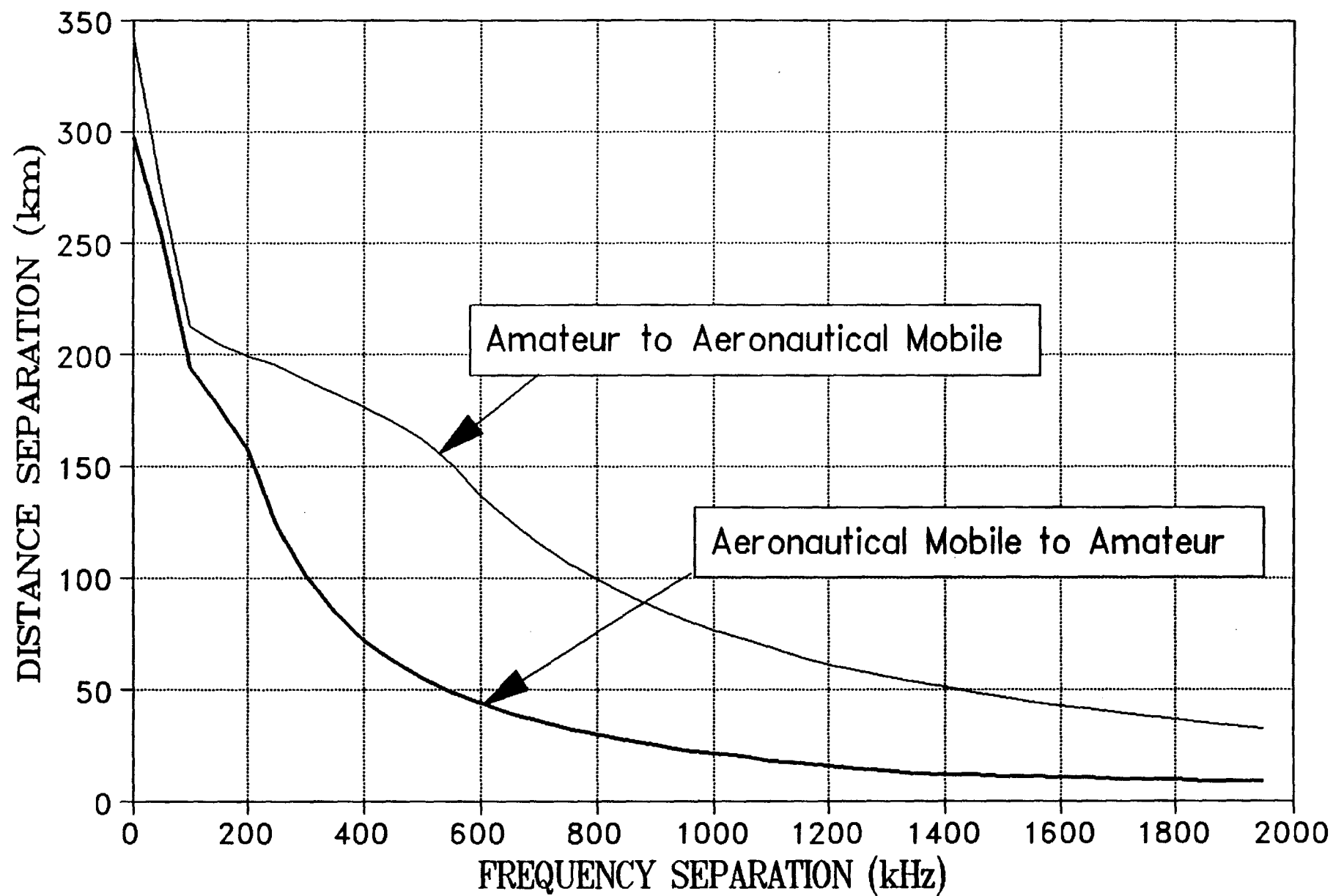


FIGURE 9 WORST-CASE SHARING CONSTRAINTS
FOR AMATEUR PACKET and FIXED

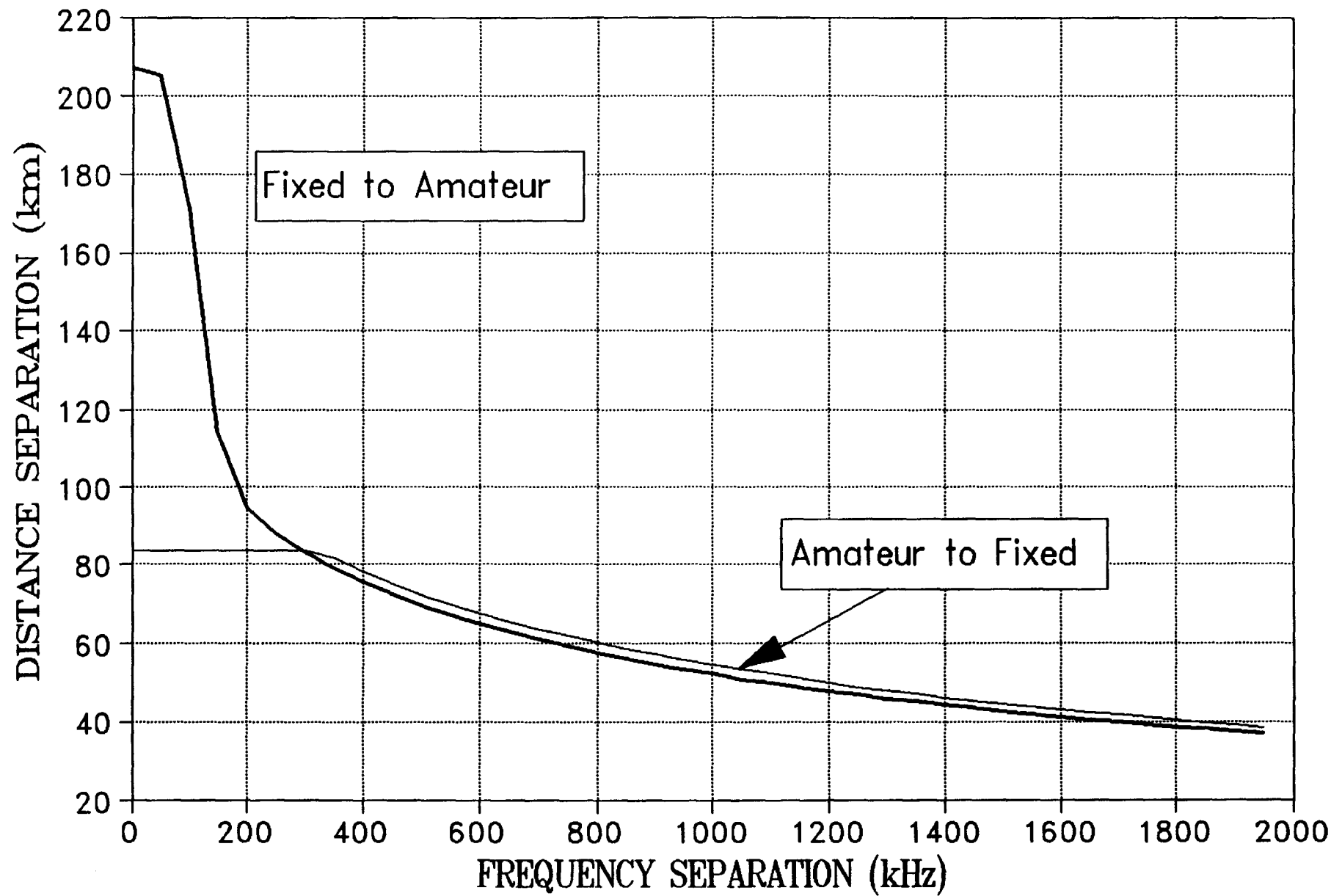


FIG 10 - WORST-CASE SHARING CONSTRAINTS
FOR AMATEUR REPEATER & MARITIME MOBILE

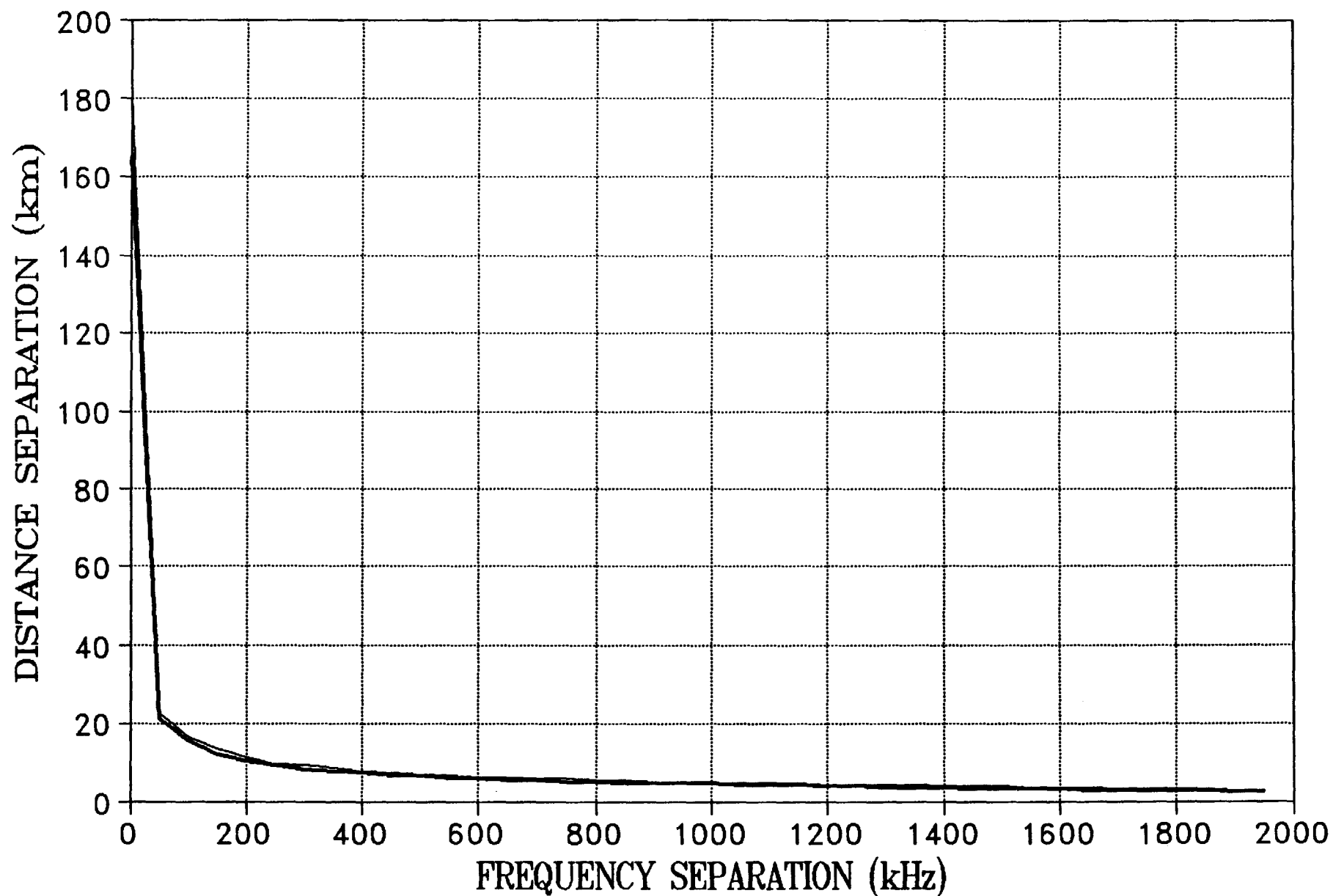


FIG. 11- WORST-CASE SHARING CONSTRAINTS
FOR AMATEUR REPEATER & LAND MOBILE

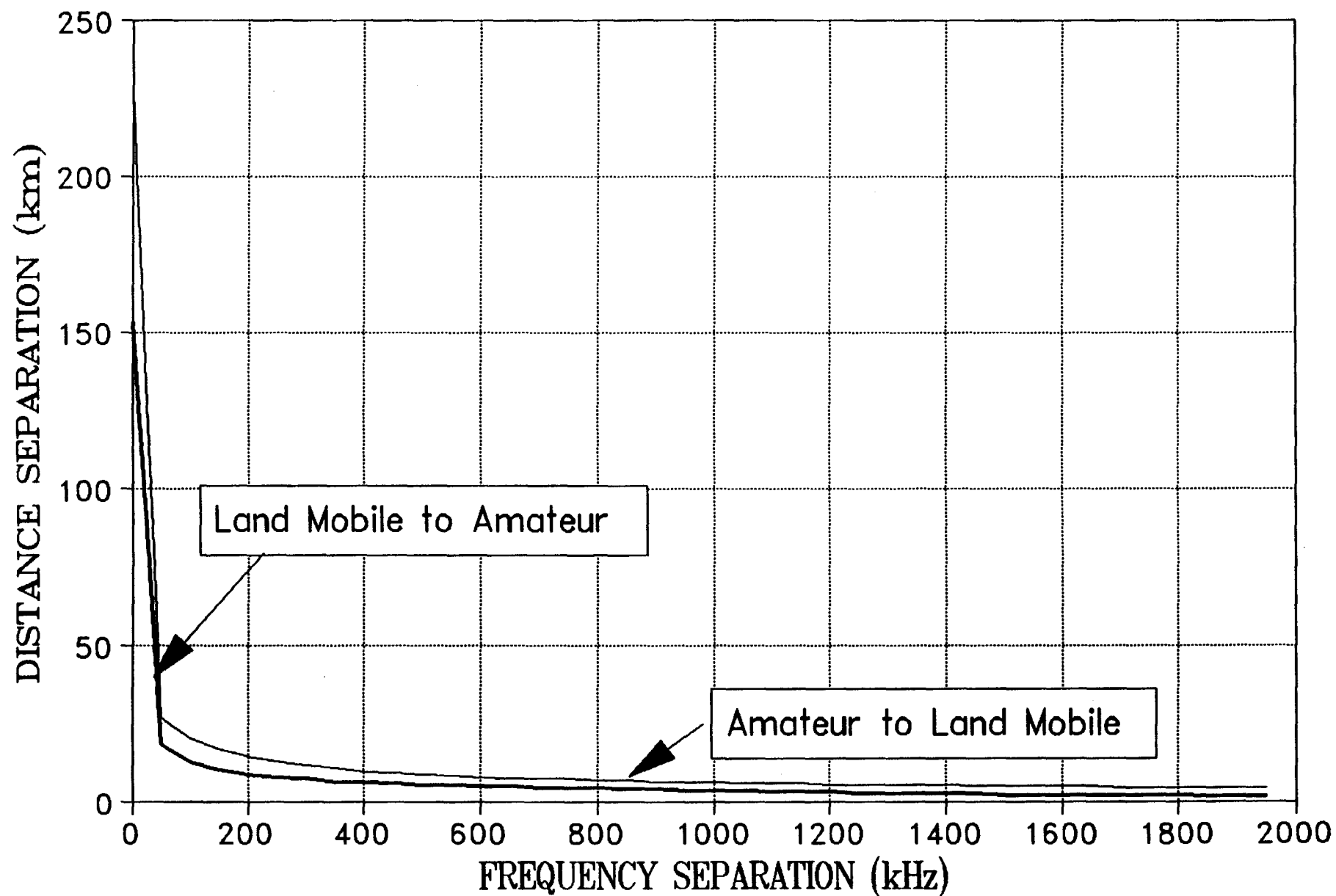


FIG 12 - WORST-CASE SHARING CONSTRAINTS
FOR AMATEUR REPEATER and TELEMETRY

